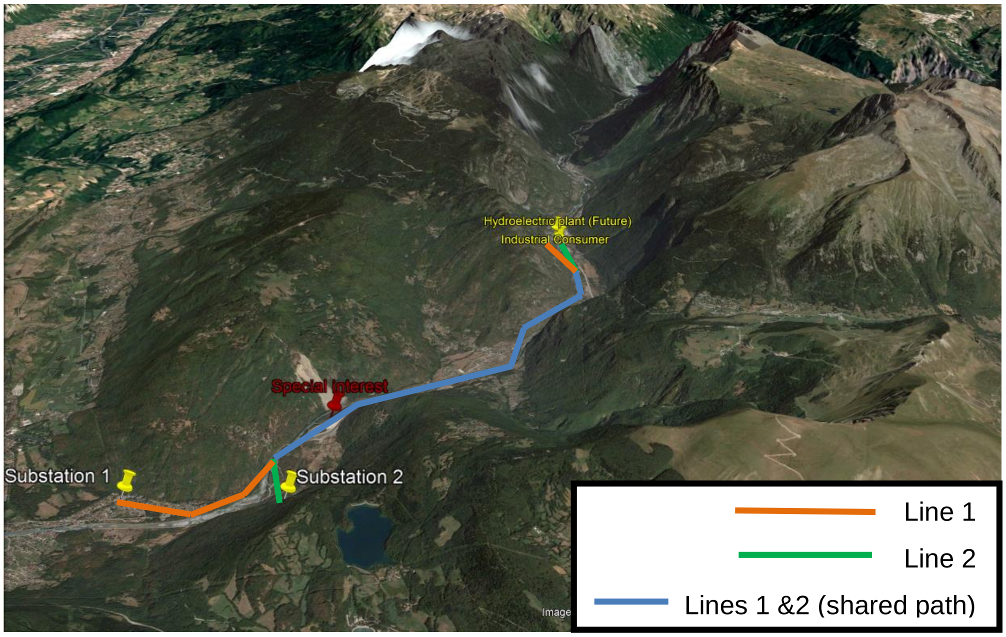
Protection of partially undergrounded HV lines with remote optical measurement

Keywords: Passive Optical Current Transformer, Remote measurement, Mixed line, partially undergrounded line, Line differential protection, Overcurrent protection, 87L, 50G

Introduction:

Protecting a couple of HV (63kV) lines running through a narrow valley in the French Alps is not an easy task. Several hydro-electric plants were connected to these lines that run in parallel for a few kilometers sharing some pylons. RTE operated the main substation (substation 1), located at the end of the valley. A new hydro-electric plant was going to be connected upstream in the valley.

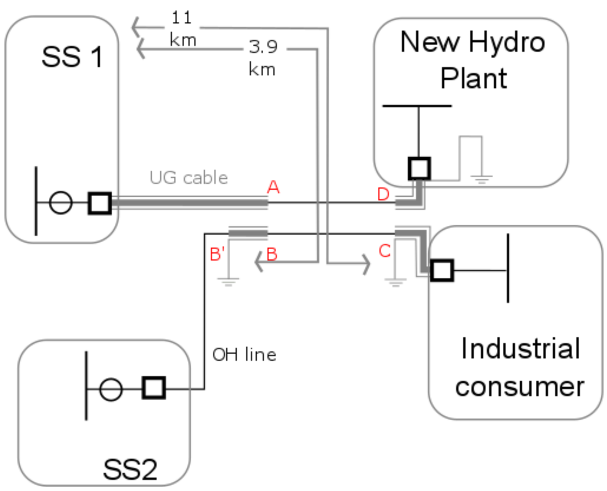
One of the lines was also serving an industrial consumer upstream in the valley, for whom supply security was critical, and penalties were applicable in case of unplanned outages. All the consumer and energy producer connections were located in places where an expansion of the substation was not easily feasible. These connections were done with HV underground cable, but most of the line was overhead.



Additionally, there was an overhead line segment crossing a special interest landscape (a riverside landslide of high geologic interest) where the presence of the HV lines was causing a significant visual impact. In order to reduce this impact, RTE decided to underground a segment of both lines which run in parallel in this area.

The challenge: Protecting the line:

The result of this would be two partially undergrounded lines running in parallel for a few kilometers, with underground cable to overhead line transitions located as far as 11km from the main substation. 100% reliable solutions were preferred over distance protections to enable or block auto-reclosing in case of faults in this line.



The resulting system would have 3 short underground cable sections that were grounded in just one end, the newest one (the entry to the new hydroelectric plant) being the only one whose earth-connection was conveniently located within the local substation premises thus easing the implementation of a traditional 50G ground overcurrent protection for that cable.

It was therefore necessary to implement at least two more remote earth overcurrent protections (at transition points B' and C) and one line differential protection (between substation 1 and transition point A). Given the lack of space due to the local conditions in the narrow valley, building a mini-substation to build a differential scheme or a remote earth overcurrent protection was not feasible option (not economically nor technically).

The solution: Remote measurement with optical CT-s

At this point, ARTECHE's SDO CFD solution was chosen to provide an easy-to-install and maintenance-free solution to protect these lines.

This solution uses the SDO FCT, a flexible, optical CT, that is easily installed at the overhead to underground transition point by wrapping the sensing fiber optics cable around the HV underground cable termination (in the case of the ANSI 87L line differential) or around the ground-connection of the three HV underground cables (for ANSI 50G).

These measurements from the passive flexible CT-s are sent to SS1 where the SDO MU CFD is located (the only electronic device in the system). The SDO MU CFD processes the measurements and it gives an auto-reclose blocking signal (Block 79) as an output if the fault is located in the cable section.

Optimizing the use of fiber optics links

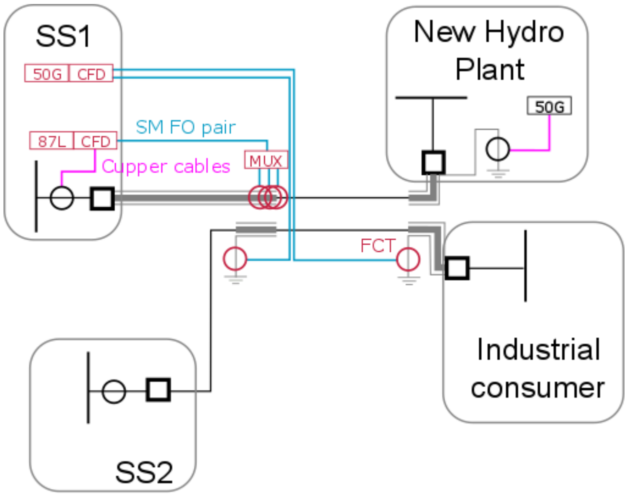
The remote flexible CT-s must be connected to the SDO MU CFD. This solution uses the fiber optics that are running together with the HV line (fiber optics are typically run together with the OPGW). Given that these fiber optics are a valuable asset for the TSO, who uses part of these fibers for internal telecom services and offers the remaining fiber optics for third parties (such as telecom operators), it is important to use as few of these fibers as possible. Taking advantage of the fact that transition points A and B that belonged to lines 1 and 2 shared a common pylon, the following strategy was adopted:

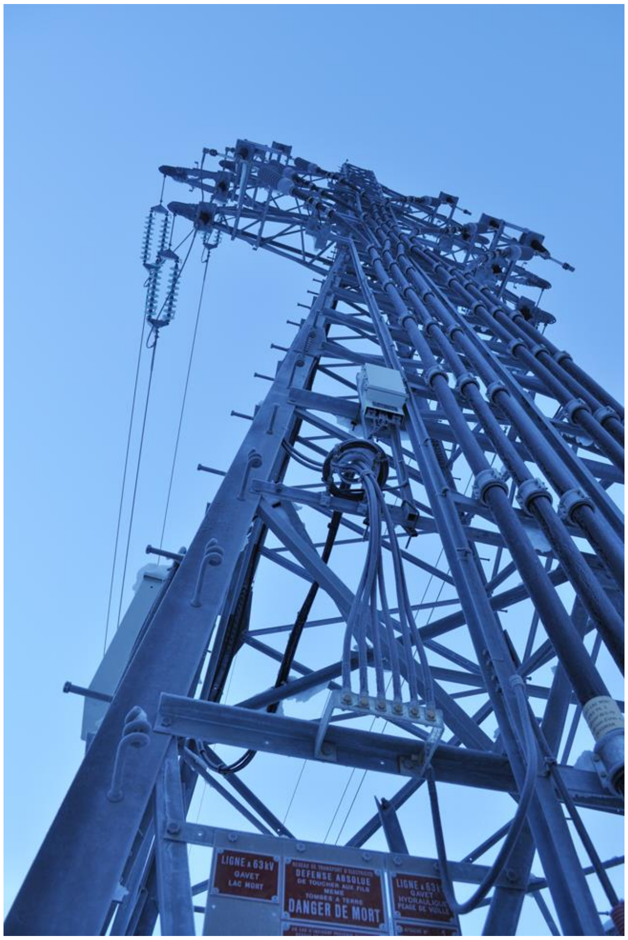
- Trasition point A: This point required 3 SDO FCT current Transformers, one per phase, for the differential algorithm. Each SDO FCT uses one pair of fiber optics. In order to reduce this, a fully passive TDM multiplexer was used, ARTECHE's SDO MUX, which allows to transmit the measurement of 3 SDO FCT Transformers using just one pair of fiber optics.
- Transition points B and C: In these cases, just one SDO FCT current transformer was required per transition point. This would require using 2 pairs of fiber optics of Line 2, and 2 more of Line 1 to get the signal to the main substation. However, in this case one pair of fibers of Line 2 was cut at the transition point B, the part going to the left was used to connect the SDO FCT serving B' and the one going to the right was used to connect the SDO FCT at C.

Results

All Project requirements were met:

- 100% reliable system to enable/block auto-reclosing on both lines
- No alteration on the overhead/underground transition points
- No works at the 3rd party substations
- Visual protection of the special interest area
- Reduced commissioning time (the whole system took just 4 days to install & commission)
- Much more cost efficient than a traditional line differential scheme
- No additional use of land
- No maintenance required
- Fully passive solution at the remote transition points.
- Future ready: The SDO CFD settings can be easily changed to send IEC61850 Sampled Values with the remote current measurement data.





SDO FCT: ground overcurrent application